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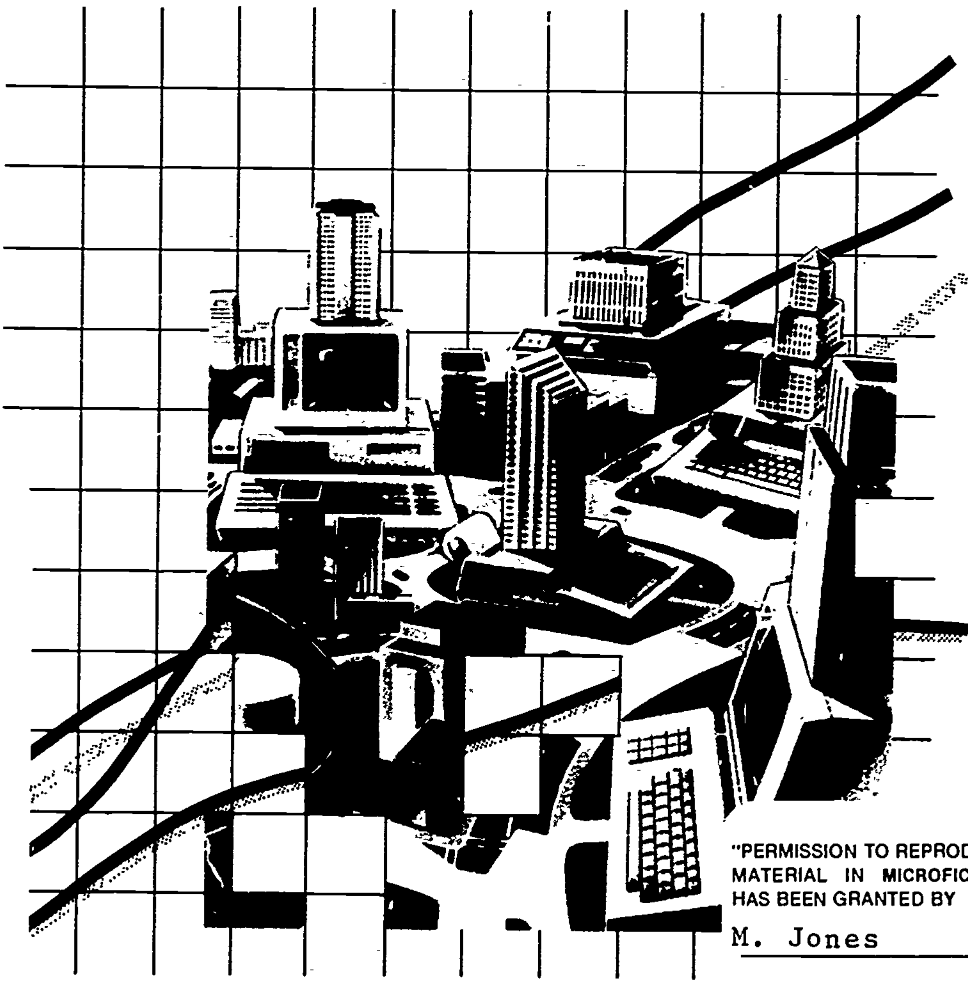
ABSTRACT

This report defines the functions of computer-managed learning (CML) as (1) test generation, correction, and analysis; (2) record keeping and reporting; (3) routing learners through a set of learning activities; and (4) charting learner progress for a variety of purposes. It then describes the hardware characteristics and configuration of three types of CML systems, including a stand alone system (the basic model), the timesharing system, and the distributed system, together with such additional devices as printers, digital pads or graphics tablets, touch sensitive screens or lightpens, mark sense readers, and videodisc, videotape, and other instructional media. The five major software programs required to fulfill the four functions are also described--a supervisor program and the registration, testing, prescription, and scheduling modules. The use of CML for the four functions noted in the definition is then detailed. Other factors that may present problems in implementing CML are also discussed, including cost, size of the learning program, accessibility, security, inappropriate use of computer testing, organizational issues, staff knowledge and skills, teacher attitudes, and isolation of learners. Guidelines and a checklist are provided for the selection of a suitable system and several available systems are described. Key factors in the successful implementation of a CML system and a brief consideration of the future of CML conclude the report. Six figures and a glossary of terms are included. (31 references) (EW)

COMPUTER MANAGED LEARNING

A MONOGRAPH



HUGH GUTHRIE

COMPUTER MANAGED LEARNING -

a monograph

HUGH GUTHRIE

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FOREWORD

In 1986 the Queensland Electricity Commission completed a project for the (then) National Training Council (NTC). The principal researchers were Frank Miller and Howard Cook. The project, entitled "Computer Managed Learning Research Project conducted within the Queensland Electricity Commission", had three main objectives:

- to assess the value and application of computer management of training, particularly for middle level employees in a decentralised industrial environment;
- to determine the cost-benefits of computer management of training as opposed to manual administration of training; and
- to assess the learning effectiveness of computer management of training compared with conventionally structured classroom training.

The present project arose from a recommendation of that report which suggested that the NTC should:

> "initiate a monograph on CML which fully explains the CML process and which distinguishes it from what is commonly understood to be CBT (ie. CAI)".

This is that monograph, which also fits neatly within the framework of another research study commissioned by the NTC. That study, undertaken by IDACH Pty. Ltd., aimed to examine the application of computer technology to the design, delivery and management of training in Australia. Its scope was to:

- analyse and describe the features and benefits of CBT systems;
- assess the current applications of CBT, identify a range of jobs it is applied to, and assess the level of success achieved;
- provide a literature search of overseas experience with CBT, and a glossary of terms;
- provide an outline plan for the future development of CBT systems in Australia.

The project managed and undertaken by IDACH Pty. Ltd. has produced five documents:

- Computer Based Training - An Introduction for Managers;
- Computer Based Training - The Field - A Literature Review;
- Computer Based Training - The Jargon - A Glossary of Terms;
- Computer Based Training - Case Studies;
- Computer Based Training - Executive Summary.

The present monograph, therefore, complements IDACH's work by focusing specifically on one important, but often neglected, aspect of computer based training - the management of learning using computers.

CONTENTS

ACKNOWLEDGEMENTS

Although many documents bear only the author's name, many others have contributed to the work. This is such a document. I would particularly like to acknowledge the efforts of the following in the production of this monograph:

- Dr. Bill Hall, the Executive Director of the TAFE National Centre, who provided my initial inspiration and suggested I tackle this monograph. He has maintained an interest in the monograph and his comments on it have been both valuable and valued.

- Others, including Frank Miller, Howard Cook, Frank Gallagher, Bob Denholm, Noel Stubbs and Ian Burns also provided their valuable insights and comments, and I would like to thank them for the amount of time and thought they have given the work.

- Other staff at the Centre including Marjolijn Jones, our Librarian, who located much of the literature used here. Marie Krelle and Lisa Pelleri provided a high quality of word processing support.

Research funding for this monograph was provided by the National Training Council.

1. INTRODUCTION

Computers have been with us in one form or another for much of this century. They have been used in training and education for many years now; however until relatively recently, their use in these areas has been quite limited. Their high cost, technical and compatibility problems, and social, political and organisational obstacles restricted their use in many fields - including training and education. Now the costs of computer hardware have fallen dramatically while the costs of human resources have risen sharply. The amount of computer software available has grown rapidly and the variety of ways computers can be used has grown too. Software has also become increasingly "friendly" to use. All this has led to the penetration of computers into more and more facets of our daily lives and work - with the consequent removal of at least some of the computer's mystique. Each day people's lives are increasingly touched by the computer. Computer literacy is now becoming a very valuable and marketable commodity - a commodity which is also increasingly expected by employers from prospective employees.

The high and escalating cost of providing both initial and further training together with with the increasing affordability of computers has led trainers, teachers, administrators and management to explore their use.

Kearsley (1984) has suggested a number of reasons for adopting a computer-based approach to training. These are:

- <u>individualisation</u> - which allows learners to learn at their own pace and by the means most suited to their individual learning style;
- <u>timeliness and availability</u> - which allow learners to learn when and where they want;
- <u>increased learner satisfaction and enjoyment</u> - learners often report improved learning satisfaction and enjoyment related to the sense of achievement given by the feedback the computer can provide;
- <u>convenience</u> - it is a particularly convenient tool if learners regularly use or have access to a computer;

- improved job performance - through improved and more uniform training and training materials (Grimsley 1984, Ufer 1984);

- reduced development time - leading to reduced time and effort required to revise and update materials;

- change agent - it can bring about significant change in an organisation or institution.

Other advantages include cost-effectiveness. This is particularly relevant when large numbers of learners are involved (Grimsley 1984), or when travel time and other costs are reduced because training can be made available in the work place (Ufer 1984) or some other convenient location, including the home.

Kearsley's book also suggests a number of roles for computers in training. These are for:

- student testing;
- the management of learning;
- instructional purposes;
- simulators - (such as flight trainers used by the services and airlines) which mimic a real system;
- embedded training - that is, where a system or piece of equipment is self-training.

Much of the impetus for using computers in a management role comes from changing notions of about how training and education should be provided to people. In the past, formal instruction has generally been given in groups. Increasingly the needs of the individual learner are being acknowledged, and processes which help people to learn when, where and how they want to are being introduced more widely. These processes are an attempt to "open up" learning and remove factors which tend to constrain or "close" learning. In 1977 Coffey (cited from Bennett (ed.), 1986) defined the concept of "open learning" and identified two broad types of constraints to learning - administrative and educational.

Administrative constraints are those which mean that the learner must:

- attend in a specific place;
- attend at definite times;
- attend over a stated period; and
- join a group of minimum size.

Educational constraints are those which mean that learners have to:

- accept the sequence of teaching offered;
- accept a teaching strategy which suits the teacher;
- accept the learning objectives already defined; and
- meet minimum entry requirements which may have little or no relevance to personal learning objectives.

The links between this list of constraints and Kearsley's list of reasons for implementing computer based learning should be evident to anyone comparing them. Moreover the list is particularly relevant if the basis for using the computer is for the management of learning rather than instruction.

In addition, assessment is no longer seen as a single event taking place at or near the end of a program. It is now more often viewed as a regular process during which evidence is gathered and analysed throughout a program so that it can be built into a cumulative record of a learner's progress. This information is used to make judgements at particular points about the standards reached as well as individual and group weaknesses. Used in this way the computer allows assessment to be seen as a way of motivating learning rather than a threatening experience. The computer allows immediate feedback to the learner and the chance of offering appropriate remedial activities when and where required. Packages may also allow the learner to have "trial runs" at the assessment. Decisions can then be made to intervene. Finally, increasing demands are being made to justify and account for the resources committed to training and education. This justification process requires that a basic set of information be collected. This information set would include the number of learners taking the program, the number of learners completing the program and those completing it satisfactorily, the average time taken to complete the program, the costs of resources used and, potentially, much more.

The three issues just discussed (the increasing use of open learning concepts, the increased number of assessment activities and their analysis and the gathering of basic information about a program for accountability purposes) all suggest the need for improved ways of managing learning programs. The computer can help to meet this need. If the computer is a tool to support and to enhance the processes of learning, training or education it can also be one which can remove some of the drudgery involved in these processes.

This monograph is concerned with one of the major applications of the computer to education and training - CML or Computer Managed Learning. Of the major applications, which also include computer literacy and Computer Assisted Instruction (or CAI), CML is probably the least visible and least discussed. Nevertheless, it is making quiet but substantial contributions to education and training (Hofmeister and Maggs, 1984). Where it is used, the role the computer plays in the management of training may be very large, significant and obvious. Its role may be also relatively small and discrete. The size and scope of its role largely depends on the awareness and needs of its users. Thus the whole learning program may not be managed using the computer. Rather, only elements of a learning program may actually be managed by the computer - for example, testing.

This monograph will explore what CML is, its characteristics, how it might be used in training or education, how to select a suitable system, some of the alternative systems available and how a system, once selected, might be implemented and managed. This generally positive view will be balanced by consideration of some of the real and imagined problems of those who may implement and use CML. Therefore it not only aims to clarify the term CML, but also to provide some practical help for individual organisations or other groups who may wish to introduce CML.

There are few software packages solely devoted to the management of learning. Some packages support testing programs, others are part of an authoring package used to develop programs of computer assisted instruction. As Miller et. al. (1986) point out;

> CAI systems incorporate a measure of record keeping, analysis etc. but this feature is dimensioned in the context of the training delivery framework rather than as a sophisticated training management system in itself".
>
> [Miller et al. 1986, p. 258]

In short, the "Management" system in an authoring package is designed primarily to support that package and the CAI programs developed using it. Although this does not preclude the use of the management component of an authoring package in elements of a training program which are not computer based, users of such authoring systems need to be aware that the focus of the package is not on the management of learning; rather, it is focused on instruction.

2. WHAT IS COMPUTER MANAGED LEARNING?

Because of the extent of the computer's potential role in managing learning the term Computer Managed Learning (CML) is not an easy one to define. Some of the foreseeable uses of CML have already been discussed in the introduction. Noel Stubbs, in his glossary of terms in computer based training (CBT) - the Jurgon describes CML as the:

> "use of a computer to maintain and analyse data on learner performance and instructional progress as an aid to trainers in selected learning activities".
>
> (Stubbs 1985, p. 15)

Christopher Dean and Quentin Whitlock in their Handbook on computer based training define CML as:

> "the use of a computer to direct students through their training and produce statistical reports on student performance or system utilization".
>
> (Dean and Whitlock 1983, p. 249)

There are many other definitions (see Maher 1983, Gorth and Nassif 1984, and Stowitschek 1985). Most of these, like the two above, do not give us a clear idea of the full potential of a CML system.

Hooper (1977) in his final report as director of the National Development Program in Computer Assisted Learning (NDPCAL), published, after five years experience in CML a definition which is probably one of the most comprehensive. He says:

> "CML applications involve the computer in helping the teacher to manage, rather than provide, learning opportunities. Four functions of the computer can be identified. First the computer can mark, generate and analyse tests, either for diagnostic or examination purposes. Secondly the computer routes the student, on the basis of previous test results, stored profile characteristics of that particular student or impressed options, through an individualised course. The individual course can be 'taught' in a number of ways - conventional teaching, self-instructional

modules, experiential and project work. Thirdly the computer stores and updates classroom records. Fourthly the computer reports on progress to the individual student, the teacher, the course developer, the administration or training manager".

[Hooper, 1977 in Grimsley 1984, p. 12]

Put simply CML is about:

1. **test generation, correction and analysis;**

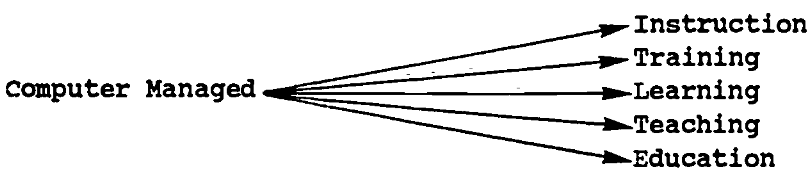
2. **record keeping and reporting;**

3. **routing learners through a set of learning activities; and**

4. **charting learner progress for a variety of purposes;**

At least two other purposes are implied: CML can be used to assist the evaluation and validation of the program and it can be used to help control the allocation and use of the available instructional resources. Thus, CML assists in the process of making learning and training more open by providing learning programs, when, where and how they can be most effectively utilized.

CML is known by other names. Stubbs (1985) identifies five alternative terms:



These terms are often (and imprecisely!) used interchangeably. However the terms disguise underlying philosophical differences. For example Computer Managed <u>Instruction</u> implies management of a process which is teacher or trainer controlled and dominated. CML, as it has already been suggested, implies that learners themselves largely control their learning. Thus CML is more oriented towards open learning than is CMI.

Although Computer Managed Learning is very often considered to be a component of the broader term Computer Based Training (Stubbs 1985) it is essentially very different from Computer Assisted (or Aided) Learning, as Hooper's definition suggests. This is because CML is primarily concerned with using the computer to help in the management of the learning process, whereas Computer Assisted Learning or Instruction (CAL or CAI) focuses on the presentation of learning experiences.

Hooper's definition also makes it clear that Computer Managed Learning does not require that a computer be used to teach. The managerial system is therefore subject matter independent and can be used across a range of learning programs also makes it clear that a computer is not essential to the learning process. The computer may refer the learner to the various learning resources available - some of which may be computer based. However, good management using the computer does not necessarily require that the computer be used in the actual presentation of learning materials. Thus CML is likely to be far less resource intensive than CAI because it does not totally rely on the use of expensive technology to develop and deliver a learning program. The computer is used to manage: it is therefore likely to be more cost efficient and effective than CAI. It offers freedom to learners and instructors alike.

Finally it must be recognised that CML is a wholistic approach to learning management. While it has a number of elements: testing, record keeping, reporting and so on, the whole of CML is greater than the some of the parts. True CML involves all the elements described in Hooper's definition. Elements of CML may be offered by a variety of software packages - including those used in CAI programs or for generating and marking tests. However these are not CML packages.

I will discuss CML and those elements which have been presented in Hooper's definition in the remainder of this monograph. Those who use only elements of a total CML package (a package for testing learner achievement for example) are not managing learning using a computer; they are merely managing an element of learning. While this may be a valuable use of a computer or computer system, it is NOT CML.

Most people who see the term CBT may tend to think more of CAI or CMI than CML. This monograph aims to concentrate particularly on CML and its various elements to redress this imbalance somewhat.

3. CHARACTERISTICS OF A CML SYSTEM

Any CML system requires the right sort of equipment or hardware together with an appropriate CML software package to make it work. This section will look at the sorts of hardware that can be used and the ways in which the hardware can be organised, or configured, to meet the specified needs.

The ways in which a software package could be set up to cover all the tasks a CML system is capable of doing will be discussed in this section. Later sections will consider how to choose and implement a CML system and package as well as appraising a few of the packages currently available which are either full or partial CML packages. Finally, of course, people are needed (or as Kearsley (1984) calls them "humanware") to develop, maintain, evaluate and use a CML system. Hardware, software and people all contribute to making a CML system work. If the correct choice of hardware is not made, certain features of the software may be unusable or the system may be very slow in responding to user inputs because the hardware cannot meet the demands made on it. If on the other hand the software is inadequate, it may not allow the full capabilities of the hardware to be realized, or it may be unable to meet new demands placed on it by its users. Finally, people are very important because they select, implement and use the CML systems. They need to have fully considered what they want the CML system to do and how it will work; for example, how will information be entered, processed, made secure, retrieved and reported by the computer? They also need to know how to use it, and use it well. People are an important but often neglected part of any good CML system.

The hardware characteristics

Hardware refers to all the computer terminals, the mainframes, mini or microcomputers, disk drives, printers and other equipment associated with running a CML system. Some systems which are capable of running elements of a CML package are very simple, requiring only a small and relatively inexpensive microcomputer and possibly some peripheral devices such as a printer or mark sense reader. Other systems capable of running a full CML package are larger and more comprehensive, possibly requiring a mainframe computer which may be linked to a number of terminals spread over great distances.

Nevertheless CML tends to use computer technology in a way which is relatively uncomplicated. Miller and Cook (pers. comm.) report that the:

> "University of Queensland Department of Economics is supporting 1500 students who take weekly tests from a CML system which uses a total of 20 terminals and two (2) printers and with very little manpower intervention. The computer is a small mini and the tests are large (3-5 hours per student/per test to answer away from the terminal.) Very little hardware complexity is involved."
>
> [Miller and Cook (pers. comm.)]

Apart from size, cost and complexity, the configuration of the system is an important factor to be considered in determining how the CML system will actually be used this in turn, is linked to the requirements of those who wish to introduce CML.

The basic model - a stand alone system

The fundamental needs are:

- a means of inputting information;
- a means of storing and manipulating information;
- a means of reporting information.

These requirements are most simply met by a stand alone system made up of keyboard, a screen, some sort of central processing unit and storage capacity (for example, a cassette tape or floppy or hard disk). Its advantages are its flexibility and portability, but it is limited by the potential power of its central processing system and its inability to share software and hardware resources with other systems. This system is represented in Figure 1.

The timesharing system

Figure 2 shows another possible configuration involving a number of computer terminals, lacking their own storage capacity but which are linked by a communications network to a central

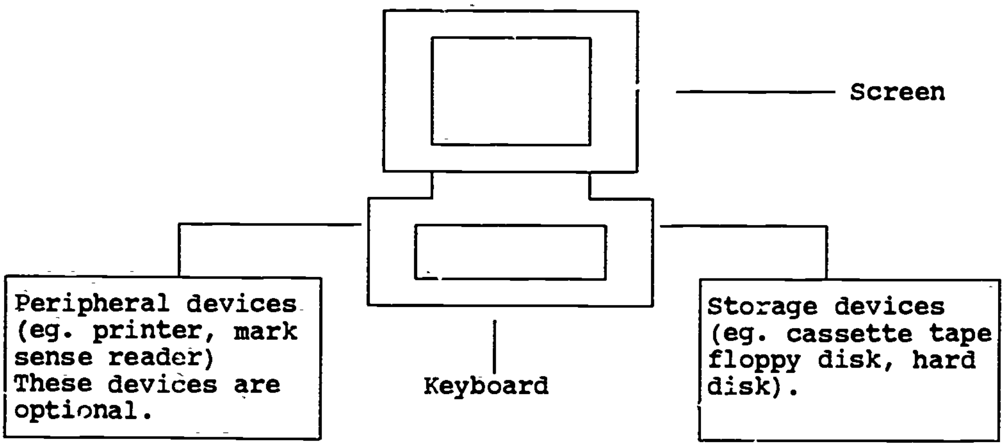


Figure 1: A stand alone system capable of running elements of CML.

processing unit (which may be a powerful microcomputer, a mini or a mainframe computer). This is referred to as a timesharing system. The communications network may be as simple as a local transmission using a system of cables linking a microcomputer with one or more terminals (a "local" network). Alternatively the network may be more complex and sophisticated, involving transmissions over long distances using the telephone lines and modems or even radio and satellite links (a "remote" network). Its advantages include a relatively large central processing unit which has potential to store a ι process large amounts of information and the relatively low cost of adding terminals to the network - they are in fact only a keyboard, a computer screen and some associated circuitry. The disadvantages include the problem of a large number of terminals connected simultaneously saturating the central processing system - particularly if that system is not all that large. Secondly, if the central processing unit is shut down for maintenance, or if it fails, then the whole network cannot be used.

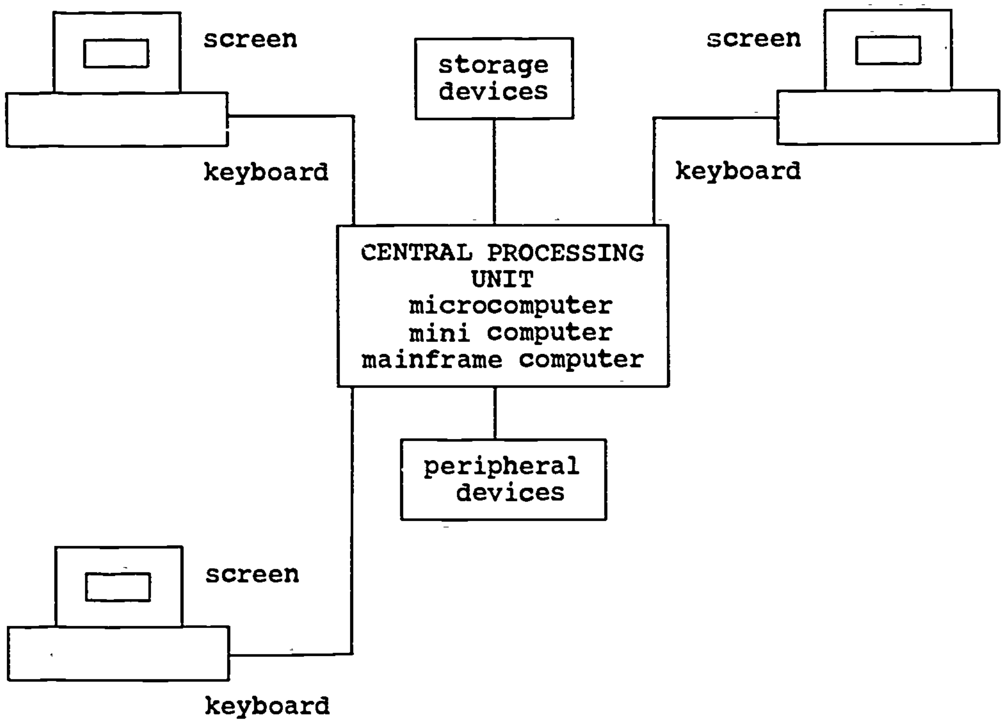


Figure 2: A timesharing configuration.

The most complex model - the distributed system

A distributed network (Figure 3) is one which combines the elements of the both stand alone and timesharing configurations. In this type of network, smaller computer systems and individual terminals and microcomputers can function independently as stand alone systems. Alternatively they can interact with each other, sharing and processing information stored in other computers in the network. Like the timesharing system, the communications system may be a "local" or a "remote" one (Kearsley, 1984).

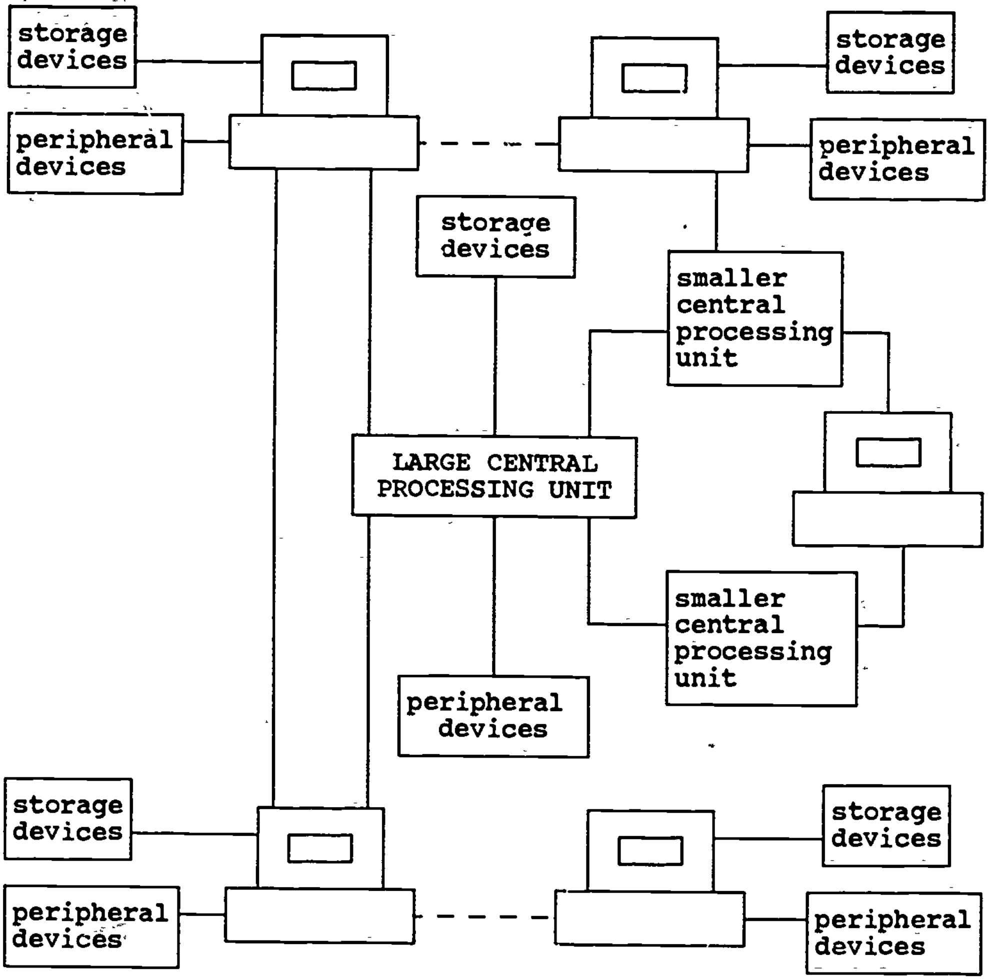


Figure 3: A distributed configuration.

The distributed system has flexibility, which allows sharing of processing capacity, hardware and software. It is not as dependent as the timesharing network on the reliability of a large central processing unit, so the individual terminals (usually microcomputers) are still able to be used for some purposes even when the central or larger computers in the network are not functioning. The major disadvantage of a distributed network is that it is highly dependent on a good, reliable and readily available communications network.

Moreover, if their knowledge about computers is limited, those using the system may not be able to take full advantage of the resources the system offers. The complexity of this system, therefore, may affect its "user friendliness". There may also be compatability problems between equipment, as well as software and cost issues, which make the distributed network less advantageous to its users (Kearsley 1984).

Additional devices

Because CML involves both the management of the learning system and student testing, a range of hardware devices can be used to complement the basic computer system. These devices are not necessary to ensure the successful function of the CML system, but they may expand available options. It is in this latter sense that they are introduced here. Dean and Whitlock (1983) consider many of the devices available (which include those that might enhance basic CML functions). A few of the more significant devices which might be used include:

printers: These might be used to print hard copies of tests, test reports, lesson plans, learning sequences and learning materials, as well as letters to learners - which may include such things as standardised comments on their submitted work (see Kuffner 1984). They come with a variety of print qualities and printing speeds - and a variety of size, price and sophistication. Printers may be a central facility, or located at one or more individual workstations in a computer network.

digital pads or graphics tablets: Keyboards may not suit everybody as a means of inputting information to the computer, and there are alternatives. A digital pad is a rectangular board on which a variety of materials can be placed (plans, circuit drawings, diagrams etc). Positions on the pad can be indicated by pressing with the finger. This information is then fed back to the computer. A digital pad, for example, can be used in a multiple choice test to find out if a student knows the position of components in given diagrams or circuits. Graphics tablets or digitisers are a more sophisticated instance of the digital pad. Here a pointer or cross wire is used to indicate position on the tablet. Another way in which a digital pad or graphics tablet

might be used is in the testing of fault finding skills. In this case readings at particular points in the circuit could be requested and given; the learner can then isolate the problem in the circuit - a suitable software package would enable the learner to be tested using critical path analysis techniques as well as providing feedback both to the instructor and the learner on his/her performance on the test.

touch sensitive screens or lightpens: These devices are similar in concept to the digital pad and graphics tablet except, in this case, users touch the screen with their finger or with a light pen. They can be used as part of the learning process or in testing in a similar manner to digital pads and graphics tablets.

mark sense readers: Mark sense readers can be used for test marking. Here a pre-printed form is used and learners indicate their selections by marking their form in the spaces provided. These readers are most suited to multiple choice and similar types of structured questions. The forms are processed by feeding them individually through the mark sense reader which is attached to the computer. This method of data entry lowers the risk of transcription errors and provides a ready data base of information about learners for analysis. The analysis may be for diagnostic purposes or to provide information about the level of individual or group performance at the end of a learning experience.

videodisc, video tape and other instructional media including simulators: Videodisc, video tape and tape-slide sequences can be computer controlled. These and other media can be used as part of the learning processes managed by the computer.

Alternatively they can be used as part of the testing system in a program. For example, in a course on conflict resolution a learner can be led through a number of scenarios, with the particular scenarios viewed depending on decisions taken in earlier stages of the sequence. Simulators, such as flight and radar simulators, are amongst the most sophisticated use of these types of media. Here the computer and other means of media presentation are used to mimic real life situations. Simulators are devices which can therefore be used for delivering training, managing training and in assessment and testing. They are, however, designed to simulate specific activities and are therefore not a generalised management system of learning.

The software characteristics

As already discussed, CML is concerned broadly with the management of learning and with testing. Under those broad headings, four major functions have been identified. These were outlined on page 6.

In fulfilling these functions a dedicated CML package is used to assist the learning process and to make it more efficient and effective. Kearsley (1984) set out the major components of a typical CML system designed to fulfil the four functions identified earlier. The system consists of a number of programs, data bases and reports. This system is shown in Figure 4.

There are five major programs. One is a "supervisor" program which controls and interprets the activities of the other four programs. These other four programs are concerned with the registration and testing of learners and the prescription and scheduling of learning and learning resources. The latter two programs are therefore concerned with learning management; the first two are concerned with the maintenance of learner records and with testing respectively. These programs may be further subdivided into more specific functions controlled by program "menus" which allow the user to select and use particular parts of the program. Between them, the four programs in Figure 4

fulfil the four major functions already identified. The programs need a number of data bases, each of which contain the basic information required for the CML system to function. These data bases consist of one dedicated to learner records, another to testing and the final one (learning activities) concerned with the learning activities and resources available. Finally, five basic reports are available from the system. Two are concerned with learner scheduling and the way in which program resources are utilized; another provides statistical information about the tests administered, while the others maintain a cumulative record on the activities of learners taking the learning program (the "class" record) and keep up to date profiles on the individual learners themselves.

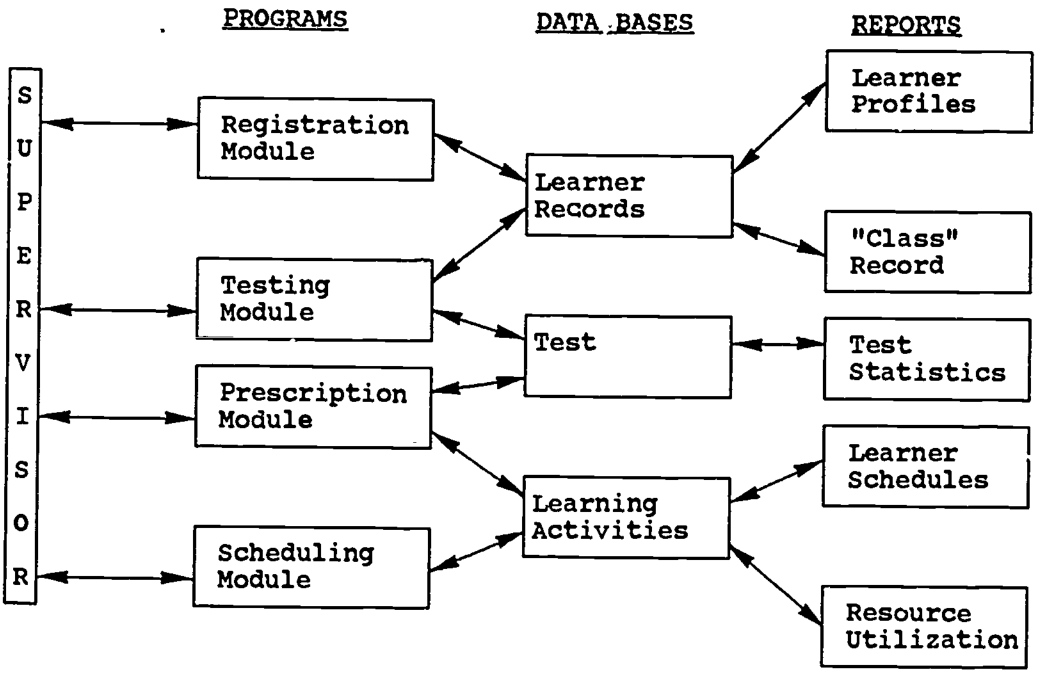


Figure 4: Components of a CML System. (After Kearsley 1984, page 25).

The way in which this system works in managing the activities of an individual learner will be demonstrated below. The sequence could be something like this:

1. The learner's name and personal details are registered using the registration module and learner records data base (Figure 4).

2. Pretests and other information are used to help select an individualised learning program for the learner.

3. A sequence of learning activities using a variety of media and instructional techniques is then generated for the learner.

4. As a result of the scheduling of learning activities for the group, the system can produce a report on the use of the learning resources, indicating which resources are being used, when they are due to be used (or were used) and how much they were used.

5. During, or following the completion of, a learning activity the learner may take one or more tests. The CML system may generate the test, as well as administering, marking and providing feedback to the learner and instructor alike.

6. As a result of the testing process, other learning activities may be prescribed to overcome problems isolated in the testing process.

7. Once competency of the learning unit has been achieved a new activity will be prescribed.

8. The records of each individual can be reported. These individual learner records may also be grouped with those of their fellow learners to produce a record of group performance. These records may be analysed statistically or in other ways to enable a profile of group performance to be established and to locate learning problems in the group or process in the instructional program which should be corrected. Reports may be used by the learners themselves, teachers or trainers, supervisors, employers, industry training committees and a variety of other individuals or groups.

9. Learners may provide feedback (using the computer) about the learning process they have gone through. This information can be collected, collated, processed, considered and reported so that the learning activities can be improved. In addition, the response and feedback about a program can be assembled - again using the computer - and used as supportive material in the accountability process.

In this way all the programs, data bases and reports available in Figure 4 are used. However, the definition and roles of CML are broad and hence a CML system may have large or limited capabilities, and can be as small or as large as its users need. It can be tailored to meet real needs and to be extremely productive.

The CML software available is of three broad types:

large dedicated packages - which are used solely for managing learning. They are relatively large and sophisticated systems which allow for the full range of CML functions, but which may be expensive to acquire and require relatively expensive hardware to support them. Because it is a large system, there may well be a need for a strong level of support in terms of system expertise, service, documentation, training etc. - at least while the system is being introduced.

small dedicated packages - these packages are also concerned solely with the management of learning. However, this type of package usually has limited capabilities and therefore, although its costs are relatively low, it can fulfil only <u>some</u> of the functions of a true CML package; it may also be limited by the type and the capacity of hardware on which it can run. Other limitations include the potential size of the question banks and the number of learners or learner records that can be supported by the system. The level of support required is usually lower than for a dedicated CML package.

multipurpose packages - these types of packages may be large or small and may be relatively expensive or cheap. They are characterised by an

ability to meet a range of functions - for example, they may be used for both *providing* and *managing* instruction. The extent to which one function dominates the others depends on the capabilities built into the software and then on the extent to which these capabilities are actually used.

In terms of the definition of CML given in section 2 only the large dedicated packages would represent a true CML system. The others, represented by smaller or multipurpose packages, are capable of managing only *elements* of the learning process or have a *variety* of functions, one of which is the management of learning.

How a CML system can be used in learner testing and in the management of learning will now be considered in greater detail.

4. HOW IS CML USED?

The extent to which the computer can be used to manage learning is variable. It is dependent on the limitations imposed by the computer hardware and software used, as well as the needs and abilities of those using the system. Deciding how to make use of CML or elements of CML might be likened to deciding how to get into a swimming pool. You can dip your toe in at the shallow end to test the temperature of the water before deciding how far in you want to go or you can go up to the deep end and dive straight in off the board. Alternatively you can decide you do not really want a swim at all at the moment and pack it in until the "weather" changes.

In helping to decide about how to implement computer managed learning (and computer based testing in particular), Denholm (1983) who represents Computer Based Training Systems (CBTS) in Australia, has suggested a number of principles which could guide the development of such a system. His list has been adapted to some extent. The principles are that:

- the system should (as for as possible) accommodate existing teaching and learning practices and philosophies. There is no sense in reinventing wheels. On the other hand, the introduction of a CML system can be a catalyst for change;
- the system developed or used should be subject matter independent;
- an instructor without a programming background should be able to use the system;
- test questions and other information can be loaded by an operator after a brief orientation;
- the delivery of exams and correction of learner answers should take as little time and effort as possible;
- instructors should retain their professional freedom to decide course sequencing, learner progression procedures, exam frequencies and prescriptions. Learners should also have some freedom to determine when, where and how they will learn. The system, therefore, is a servant, not a master;

- the system should handle routine matters to allow the instructor more time to meet the needs of learners on an individual or group basis;

- information held on the system should be secure so that it cannot be misused or tampered with; and

- the system should be capable of being used by learners with little or no supervision.

Computer hardware and software and how a CML package can work in managing the learning process, has already been discussed in broad terms, as has the computer's role in testing what, and how much, has been learned. These two major uses are now discussed in greater detail.

The use of computers in management

Computers have a number of roles in learning management. These include:

- record keeping and reporting;

- directing or routing the learner through the program;

- managing instructional resources; and

- maintaining, evaluating and validating the program.

Some of the advantages in having computers involved in training have already been discussed (see Chapter 1, pages 1 and 2). Other advantages are implicit in the management roles identified (see Davis 1978; Grimsley 1984 and Ufer 1984) above and include:

- the ability to schedule the use of scarce resources optimally;

- the rapid identification of learners having difficulties so that effective remedial action can be taken;

- instant and impartial feedback to learners;

- the systematic improvement of assessment methods and learning materials through evaluation;

- the ability to cope with an unexpected increase in learner demand at relatively short notice and without major increases in resources or, alternatively a similar ability to cope with a significant decrease in numbers; and

- the ability to free instructors from tasks which are essentially routine record keeping and clerical duties and to allow them to undertake the more critical task of assisting learners, especially those experiencing difficulties.

The management roles identified will now be discussed more fully.

Record keeping and reporting

Figure 4 sets out 5 basic reports that a typical CML system might generate. In addition, one of the data bases is specifically devoted to keeping learner records: records can be maintained for each learner in the program, setting out his or her progress and performance in the learning program. This might include starting and completion dates for individual modules, the learning resources accessed and used, time of day and date on which tests were taken, number of attempts at tests, test results, entry and exit levels of performance on pre- and post-module tests, instructor interaction with the learner and files of information sent to, and received from, the learner. These records can be used to generate reports for the learner, the instructor and others interested in what the learner has achieved. Individual records can also be combined, analysed and reported to produce group records which can, in turn, generate reports of a more general form. These reports have particular value in program evaluation and validation. Record keeping and reporting keep the learner informed of their progress. The records also allow the instructor to make informed decisions about the level of learner progress by individuals or the groups. Appropriate action can then be proposed and taken.

Directing or guiding the student through a program

Many learning programs are structured in the form of blocks or modules. Barker _et al_. (1985) point out that using a computer

to direct or route learners through a sequence of learning experiences demands a careful analysis of the subject matter and requires:

- the precise sequencing of instructional objectives - which clearly define the expected outcomes of learning;

- the careful selection of associated learning activities - which defines learners' work programs; and

- the construction of tests - which aim to measure either characteristics of learners entering the module or block of learning (a "pre-test") or a "post-test" which measures the extent to which learners have achieved particular stated learning objectives.

The TAFE Board of Victoria's report on the statewide development of CML and CAI published in 1982 described the CML system in use at the Southern Alberta Institute of Technology. In this system learners are guided using a series of "maps" and "flags". The maps provide a pathway through the module, and direct learners to appropriate learning resources. A very general type of "map", which sets out the key elements in a computer managed learning system, is presented in Figure 5. The program map prepared for each individual establishes the areas to be studied, the time for pre-tests or post-tests, the mastery level required, the composition of questions in a test, who can obtain a particular test from the computer, whether answers are to be provided to the learner or not, the number of times a test may be taken by a learner, and other parameters for establishing the program of instruction, or course, to be undertaken. These parameters could be instructor designed or established in consultation with the learner (TAFE Board 1982). The maps will therefore vary for each learner and will be dependent on their performance in earlier learning activities, the performance in any pre-tests, their preferred learning styles, and so on. Once the course map has been established the learner may undertake the program. The instructor maintains a monitoring role through the learner management facilities of the CML system. Individual or group performance can be monitored, feedback provided, minimum progress dates established, management decisions concerning additional instruction implemented and other appropriate action to assist individuals can be undertaken using the package (TAFE Board 1982).

Flags are a checkpost used so that learners cannot proceed past a certain point without having completed specific prerequisite

activities. Flags therefore ensure that learners do not lose sight of the learning program as a whole, or attempt activities for which they have not been adequately prepared.

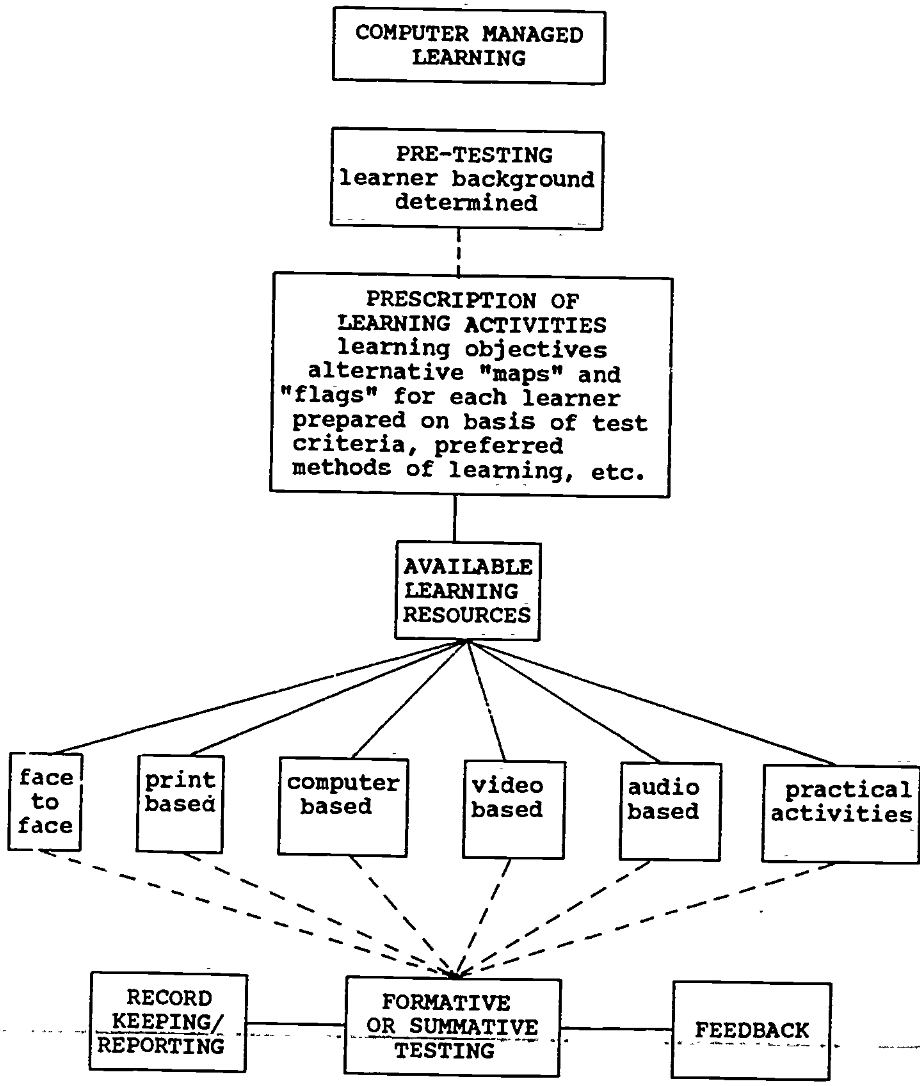


Figure 5: Key elements of Computer Managed Learning. (Adapted from Barker et al. (1985) p. 28).

Using the computer in this way has the potential to save a considerable amount of both the learner's and instructor's time. However those developing or using CML systems have to be mindful that CML "guiding" may be mechanistic and prescriptive

unless some care is taken to ensure that the system is "open" and leaves important elements of the program (content selection, pacing and sequence) to some extent in the hands of the learner (McMahon 1978).

Managing instructional resources

Figure 5 shows the great range of learning resources that can, potentially, be used in any program including print based materials (such as worksheets, textbooks, workbooks, problem sheets, tests, etc.), audio or video tapes, tape slide programs and computer packages. Practical activities, including project work and other face to face activities (such as lectures, seminars, tutorials and other group or individual activities) can be programmed for an individual learner using the computer. One of the consequences of using computers in managing an individual learner's program is that the use of available learning resources can be planned and monitored so that each is used efficiently and effectively. In this way fewer actual learning resources are usually required than traditional lockstep methods of instruction. This is because learners will most usually be at different stages, and therefore not requiring the same resources at the same time. Using an appropriate part of a CML package, learners may be able to "discover" the range of resources covering particular aspects of the program for themselves. Thus, learners can locate and use the resources which most suit the ways they like to learn; control of learning is returned, to a certain extent, to the individual learner.

Maintaining, evaluating and validating the program

The information contained in the various data bases of a CML system can be analysed and reported in many ways. There are increasing demands to account to others and to demonstrate that the program offered is meeting the needs of those who use it. To do this the available information in these data bases can be manipulated, analysed and reported. Much of this process will be considered when the use of CML in testing is discussed. The present topic extends beyond the concept of assessment, however, because testing for competence or even mastery of program content is not the only issue. Here the computer can help to provide the information that those interested in the program need to know. These people include learners, instructors, managers, administrators, employers, statutory authorities and other government bodies.

The learning materials, tests and other elements of the program can be improved (or replaced) by not only analysing the available information, but also by obtaining feedback from users about the program using the computer. The program evaluation and validation process may lead to the addition, replacement, or deletion, of small or even large parts of the program. Such a process of evaluation is described by Kuffner (1984).

The use of computers in testing

One of the most basic of CML applications is the use of the computer to mark, generate, administer and analyse tests. Testing is the means of seeing whether learners have mastered the program's objectives; it can be used to help determine whether learners are, in fact, competent. Testing has a formative role too; it helps to establish how well learners are doing at particular points in the program. Tests are sources of information. Test results can also used for accountability purposes and for certification.

Specifically, computers may be used in the following ways:

- Question banking - including item editing and evaluation;
- Test generation and printing;
- Test scoring and analysis; and
- Item generation.

Most testing will probably be done off-line with the computer generating and then printing out a suitable test. However, if the computer is used directly in testing, care must be taken to ensure that the learner spends more time learning to manage the computer than being tested (Mizokawa and Hamlin, 1984). Moreover, in preparing individual items or question banks, the established principles of testing, including item construction, should underlie any program of computer based testing For example, the formatting of tests should be carefully considered especially if the test allows the learners to enter their responses directly into the computer - that is, through interactive testing. In this case, the limits of a computer screen need to be kept clearly in mind. Those taking the test should also be allowed to control the presentation rate of the test items - even if the time taken to complete the test is

being monitored by the computer (Mizokawa and Hamlin 1984). It has already been suggested that tests can be used to help identify strengths and weaknesses (formative testing) or to make judgements about an individual's level of ability (summative testing). The testing mechanisms, whether computer based or not, therefore need to have their predominant purpose clearly identified.

Question banking

Question banks consist of a large number of test items of various kinds which contribute to an assessment of the level of student progress and achievement. The questions can be gathered from many sources and, in a number of cases, have been set up and managed through contributions by a consortium of organisations. The bank may form a part of the testing data base (see Figure 4).

Question banks are seen to have a number of advantages:

- a large pool and range of suitable questions can be assembled and used to generate a large number of tests;
- the tests produced can be individualised, yet are broadly at the same level of difficulty;
- testing can be undertaken at any time;
- the large number of items in the question bank increases the security of tests when learners do the same level of test but at different times;
- the test data gathered are more comparable across groups; and
- learners can have trial runs before summative assessments.

Naturally any question bank is only as good and as valid as the questions it contains.

The characteristics of question banks are set out in a document entitled CML General Overview published by TAFE and Computer Based Training Systems Ltd. This document suggests minimum requirements for an effective CML system. It suggests that the question bank must be capable of being:

- **structured** - so that each question is stored in a unique location in relation to (for example) the part and objective of the program to which it relates. Each question may also be coded in a variety of characteristics to allow maximum flexibility in the storage and recovery of that question. Typical characteristics should include the type of question (multiple choice, completion, true-false, short answer etc.), the cognitive level of the question, item difficulty, the correct answer(s) expected, the number of answers expected and, possibly, some form of security system with a number of levels of security to control the degree of access to the bank; and

- **edited** - so that questions can be added, deleted and updated. Test editing can be even more sophisticated however. For example, Kincaid et al. (1983) describe an extension of the Computer Readability Editing System called the Instructional Quality Inventory (IQI) which, amongst other things, provides a checklist for analysing test items so that better tests are produced. Its features include checking spelling, flagging uncommon words, detecting double negatives and long sentences as well as calculating levels of readability. In this way items are edited and can be evaluated to some extent prior to their introduction. Items may be further improved by an analysis of their performance in use.

Finally it may be possible to "chain" various question banks so that test selection can be made from one or more of the banks available in a data base.

Item generation

Item generation is a specialised form of test generation. In its simplest form, the individual test items are based on a basic question outline, with the questions being individually created when the test is prepared. Usually this process involves generating specific numbers or words to complete certain items. The range of numbers or words is specified and the computer keeps a record of the correct answer for each item generated. The advantage of this system is that a large number of essentially different items can be produced using the same item form. The concept of item generation can be extended further where, for example a listing of a business's monthly

income and expenditure could be generated and the learner asked to prepare a balance sheet. The number and types of expense and income items can be manipulated more or less infinitely, producing a considerable variety of test items of varying difficulty. With careful thought, this form of testing is applicable in many situations - and is a very effective means of assessment.

Item generation can be used for testing off-line, but it makes considerable sense to use these types of items for on-line testing as well. However this use of off-line or on-line testing is a cost benefit 'ssue, and requires careful consideration by those using the CML system. Will the increased costs of on-line testing be offset by gains in other areas?

Test generation and printing

Using one or more question banks, and some form of course prescription, tests of comparable difficulty can be prepared. . program can assemble the individual items into a test by either random selection or by selecting the number and type of items on the basis of specified criteria; for example, weights can be assigned to particular criteria to provide the number of items needed to test each criterion effectively.

The form of answer that the computer will accept and how the testing process will work, require careful consideration; for example, are learners able to change their minds after they have already made some response? How will the computer cope if learners spell critical words incorrectly in their answers? Can learners move forward and backwards through the test? What type of answers, and therefore guidelines, can the computer cope with?

Tests may be printed out for off line testing or displayed on a screen for on line or interactive testing (Kearsley 1984). The program may also be capable of printing an introductory page and individual page headings for the test and generating answer keys for use in manual scoring. Alternatively, tests can be scored automatically by optical scanning techniques using mark sense readers (see Chapter 3, additional devices, page 14). Examples of test generation programs specifically designed for micro-computers are discussed by Brodeur (1986).

Test scoring and analysis

Using computers to score tests and to analy e the res obtained both by individuals and groups of learners is ^ne the oldest and most common uses of computers in the managem of learning. It has already been demonstrated that a test cai specified, administered and then scored by computer. Leai - responses to tests can be entered directly into the computei itself through <u>interactive testing</u>. However, learner responses can also be entered manually by support or teaching staff, or automatically using an optical scanning device such as a mark sense reader. A more sophisticated form of interactive testing is the process whereby the test is administered item by item and the type or difficulty of the next test item depends on the answer given to previous items. This procedure is called <u>adaptive testing</u>. Fewer test items are usually required to test a person if adaptive testing procedures are used.

In scoring a test the program should at least be able to:

- list individual learners by name;
- indicate which of the test items they did and did not attempt; and
- indicate whether their responses to each item attempted were correct or incorrect;

The program should be able to calculate a final grade for each learner (number correct and/or percentage) if this is appropriate. It should also be capable of producing reports for use by the teacher, the learner and others if required.

In analysing testing data, the program might:

- provide an insight into individual and group weaknesses;
- calculate average group scores on particular items;
- record for each learner the date, time, questions generated and answers inputed;
- analyse individual test items to determine how useful each of them is for predicting overall learner performance;
- combine and analyse an individual learner's performance on various tests;

produce reports for use by instructors and learners; and

- analyse the questions individually to determine how the individual learners, and the group as a whole, responded to each. This process enables the test items themselves to be improved, the learning program itself to be evaluated and the strengths and weaknesses of the group, or individuals within it, to be isolated and addressed.

If test data are analysed the quality of testing should be improved.

Finally it may be useful to know when, and how often, learners attempted tests, and how long they took to complete either the whole test or particular items in it. These records can be useful in evaluating the effectiveness of the test and the learning experiences on which the test is based.

5. CML - ANOTHER PERSPECTIVE

To this point a generally rosy picture of CML has been painted. It can, and does, have considerable advantages - and many of these have already emerged in this monograph. On the other hand there are a few potential problems associated with CML. Caveat emptor - or (roughly translated) "Let the buyer beware" - applies equally in CML as other things. Therefore the monograph will now discuss problems, or rather caveats, which should be borne in mind by those who might introduce or use CML. This section provides an appropriate introduction to the following section of this monograph, which will look at some of the methods and criteria which could be used to select a suitable CML system. Caveats include:

- cost — There is, potentially, a large investment of money and time in selecting, purchasing, installing and beginning to use CML.

  The costs of maintaining and adding to the system may also be relatively high. Naturally the costs associated with setting up the system will depend on the existing equipment as well as the size, and sophistication of the chosen system. Computer hardware and software are constantly changing, and it is hard to know when to make an initial investment of time and money and, moreover, whether the investment will be viable in the longer term. On the other hand, if CML is a useful strategy users have to start sometime. The real skill comes in choosing the "best" time to start. However, because of its nature CML will generally be more cost effective than other forms of computer based training , for examr' CAI.

- size of learning program — CML is usually introduced to he to liberate instructors from routine tasks such as record maintenance and testing. Nevertheless the nature and size of the program must be considered,

and there may be an optimal number of learners and certain type of learning program for which CML is an appropriate management tool. However, if learner numbers are relatively small it may not be worth the effort needed to establish and maintain a CML system.

- __accessibility__

One of the guiding principles of the Southern Alberta Institute of Technology's learning management system identified in the TAFE Board report on CML (1982) was that the instructor can use the system without a programming background. In short, this means the software should be "user friendly". This user friendliness usually relates to the software, but should also be extended to the software documentation. This documentation should be as brief as possible and easy for someone without a strong computing background to understand. The friendliness also needs to include the system's users for, if it does not, the learner and instructor alike will spend more time in trying to cope with using the computer than in learning and teaching.

Accessibility also extends to the question of the suitability of the software for particular computers and or systems. In short, there are compatibility considerations. In a distributed system (described on page 11) a variety of hardware and software is usually combined. As computer systems (whether they are used for CML or not) tend to grow and develop with time, compatibility is usually an issue of concern - with each new piece of hardware or software added bringing its own set of problems. Solving compatibility problems may, in turn, reduce accessibility or "friendliness". Finally, there may be considerable difficulty in finding a software system

which meets all the identified needs of its potential users. Thus, unless the software has been tailor made, or the users are capable of producing it themselves, it is likely that any software purchased will meet certain needs but not others. The various requirements then have to be weighed up with the system finally chosen, essentially representing a compromise. This becomes really important if the system has no capability of expansion, or when the system is not capable of meeting important new or existing needs. It depends on the capacity of an "off-the-shelf" CML software package has built in and how much, or how readily, it can be adapted. Many CML systems clearly have usability problems.

- <u>security</u>

Many people are uneasy about the amount of personal information stored in computers (Grimsley, 1984) and its security. Moreover, there is no absolute guarantee that people are who they say they are when they are undertaking a test generated by the computer. Learners can therefore cheat the system (and ultimately themselves) very readily. The answer is found in the use of appropriate security systems ensuring that only those entitled to access particular information can, in fact, access it. Nevertheless, Tony McSherry's (1984) article on computer use at Richmond College of TAFE in Victoria makes instructive reading for those concerned about the very real problems posed by the computer "terrorist", who regard it as a challenge to "crash" computer systems or gain access to restricted computer files.

- <u>testing</u>

While CML can be used to test the achievement of a wide range of learning outcomes and learner attributes it is

not appropriate to all testing circumstances. Macleod (1984) has suggested, for example, that testing psychomotor skills, certain types of interpersonal skills, some highly complex types of mental processes and on-job skills are not appropriate uses of computer-based testing. It is important to be realistic about what the computer can validly test. Those designing and using learning programs must be prepared to adopt other testing procedures where it is not appropriate to use a computer. The potential danger exists that the computer could be used too much rather than too little.

- <u>organisational issues</u> In many cases it is not software or hardware considerations which affect the introduction and use of a CML package. Rather, there may be barriers within the organisational structure which impair or effectively prevent its effective introduction and use.

  If an organisation wishes to upgrade the skills of its workforce or introduce new procedures using a CML package run on the organisation's computer network, any bureaucratic impediments to its use need to be overcome. For example, how compatible is a CML-based approach with the way instruction is currently delivered? How willing are people to change current practice? Will supervisors actually allow their staff time to access and use the CML package on the organisation's computer when their other work permits? Are people in the organisation willing to commit computer time and storage capacity to implementing a CML system? What regulations or staff terms and conditions agreements stand in the way of introducting CML? These are but a few of many ways in which organisational

issues can affect the introduction and use of CML. It is important to note that educational organisations are not immune to these organisational problems either!

- <u>staff knowledge and skills</u> I have already argued that a CML system or package needs to be accessible. An important issue emerges if actually <u>using</u> the system presents a greater problem than trying to use the system or package to teach and learn. Duttweiler (1983) has suggested that a lack of computer skills amongst staff and, at an extreme, computerphobia, is a barrier to using the computer for any purpose - including CML. However Burrowes (1985) claims the older trainer can adapt - and offers a series of training hints. The use of teams of people whose individual members have complementary expertise is one way of addressing the issue of inadequate computer skills. However if this expertise does not already exist in the organisation it may have to be brought in either on a short or longer term basis. This sort of up-front cost may require an organisation to have a substantial and long-term commitment to CML - a commitment it may not be willing to make until it has seen some of the results. If the expertise does exist within the organisation, the success or otherwise of the attempt to introduce CML will depend largely on the political skills and vision of those with the expertise. If they are politically inept and lacking imagination their effort will be met with a mountain of the organisational resistance which has already been discussed.

<u>attitudes</u> Many instructors have a natural fear that by allowing computers to take over part of their teaching or management role they will somehow lose control and prestige - their self-image will

suffer. They may fear that they wil become dinosaurs in their own classrooms. This is not the intent of CML of course; it is designed to free teachers or instructors from at least some of the routine tasks the job entails.

There is a fear amongst some teachers that they will lose their central role in the learning process - rather than being performer in front of the class skilfully manipulating and presenting information they become facilitators of other peoples' learning. In short, they change from a controlling role to a helping role. For some, this sort of change in role can be different to accept.

- <u>isolation</u>

A CML package is one way of allowing learners access to instruction when, where and how they like. However, because each learner program is an individual one, the package may tend to isolate learners from their fellows and the instructor. Thus, while the CML package may provide a splendid learning experience in every other way, group experiences which help to satisfy the needs for companionship, affiliation and belonging may be lacking (Grimsley 1984). Care should be taken to ensure that such isolation is prevented as much as possible. Another form of isolation is likely. Because the number of staff with computing expertise and knowledge of CML systems is relatively small, and they tend to be isolated as individuals rather than concentreated in groups, their "isolation" may be used to ensure that the proposals for introducing CML, however virtuous, are delayed or ignored.

Given all this, how does one go about selecting a CML system and what sorts of questions should be asked in choosing one? These issues will be addressed in the next section.

6. SELECTING A CML SYSTEM

Introducing some form of CML may represent a very substantial investment for an organisation. Even purchasing a small package for scoring and analysing test data may be a considerable drain on very scarce resources. Because of this, software and hardware alike need to be selected carefully to ensure that they are suitable for those using them. There are two issues concerned:

- feasibility - which involves weighing the costs and benefits to determine whether or not CML could be useful in solving a particular problem;

- selection - having specified the problem and decided to use CML to solve it, a system is selected which will, in fact, solve the problem.

The selection process can vary in its scope and formality. It will probably be lengthy and formal if a major purchase is being contemplated; for less significant purchases the process may be relatively informal and brief. It may involve a pilot phase to determine whether or not CML, or its elements, are worth adopting and using in the longer term and on a more extensive basis.

The stages which might typically be involved in selecting a suitable CML system are outlined in Figure 6. These stages are discussed in detail below and represent the process used for a fairly lengthy and formal section procedure. The steps can be modified for a selection process which is less formal and therefore usually more brief.

Essentially the process begins by identifying a problem or an opportunity to use CML. While the flow chart presented in Figure 6 focuses on the selection of a commercial package of some kind as a solution, it is important to remember that this solution is merely one potential outcome. Other outcomes may be that:

- CML in any form is not an appropriate solution given the circumstances; or

- a CML package is viable, but nothing available commercially meets the required specifications.

The problem or opportunity is then specified by defining the critical issues of the problem and putting them into context.

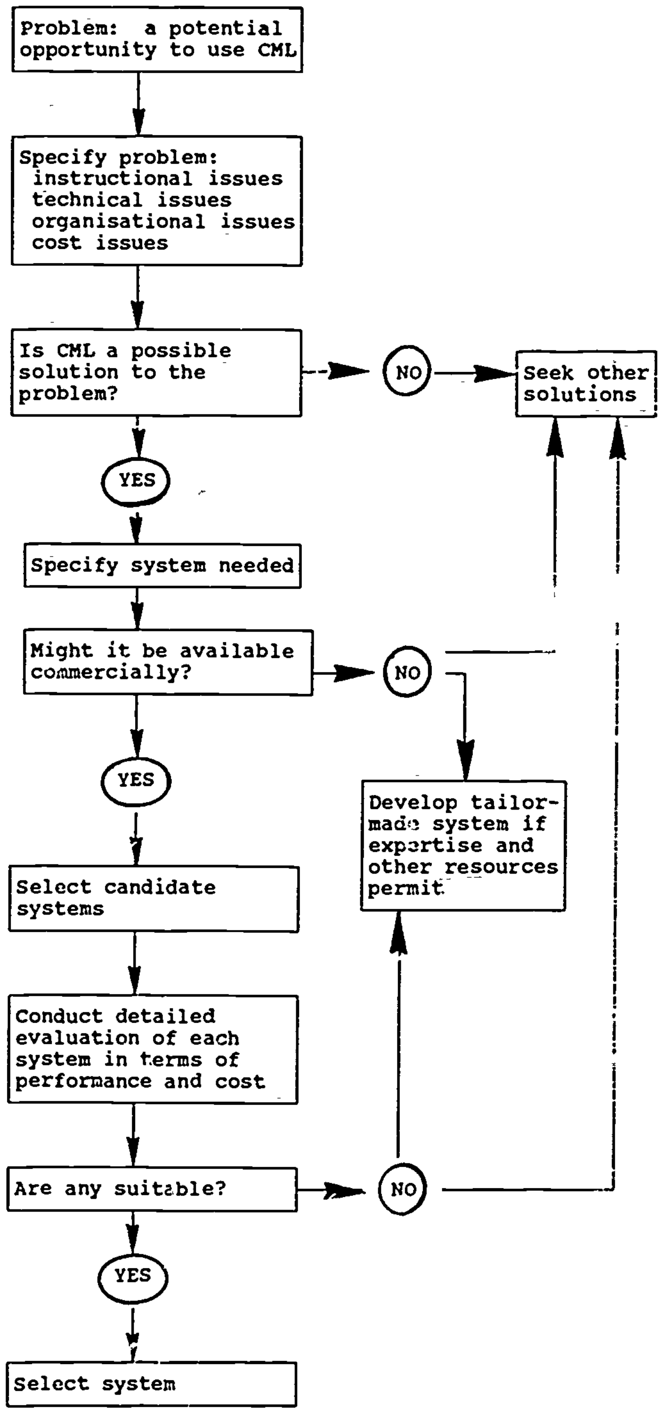


Figure 6: A flow chart for selecting a commercial CML system.

Broadly these issues are instructional, organisational, technical and economic in nature. Having specified the problem one needs to ask whether CML represents a possible solution. If it does, (and there may be other viable solutions at this stage) then the investigation proceeds further by using the information already collected to specify the CML system needed. If it is possible to purchase the system commercially, information is gathered about potential alternatives. Candidate systems are selected, and then evaluated and compared using the specifications already developed. This may be accomplished using the CML system in a pilot study, in which the CML system is actually tried out. If at least one CML package proves suitable it may be selected, purchased and introduced. More will be said about implementation shortly. If none is suitable, but CML is the most viable solution to the problem, then the development of a tailor-made CML system may represent a solution. This assumes, of course, that the resources and personnel to undertake this sort of development are available. A list of potentially critical questions which could be asked when trying to select a CML system has been included later in this chapter.

A team capable of solving the initial problem at the top of Figure 6 needs to be selected. This group would need a suitable range of expertise to ensure that the problem was properly specified. The group needs to be balanced too; it should not be constituted so that it is likely to focus totally on either the positive or negative aspects of the problem. The team's view needs to be a balanced one.

Problem specification

Four broad issues usually require consideration by the group in specifying the problem. These issues are:

- instructional;
- organisational;
- technical; and
- cost.

The instructional issues may involve an examination of existing practices, that is, the existing learning programs in place, how they are managed, what they teach and so on. Alternatively, the problem may be that a totally new program is needed, or that training has never been attempted in that area or by the organisation before. Because the starting costs for CML may be high, its viability in the longer term needs to be questioned.

CML is most useful when there are high learner numbers, or moderate numbers in a program with a long term viability. The clerical capabilities of CML are of great use in both these cases. If there are small numbers of learners, but implementation of the program is absolutely essential CML may still be feasable if it allows students to study the program when and where they wish, and if it releases staff and if it manages scarce resources better than if the program were managed by more convential means. CML may be useful if testing and detailed monitoring of learner progress and resources usage is required. It could be a practical way of specifying and directing learners to a range of available resources and learning authorities. All of these and other instructional issues need to be considered in helping to specify the identified problem. In short, two questions must be asked:

> "What role might the computer have in managing the instructional process?"

and

> "Will the benefits gained outweigh the costs incurred?"

The organisational issues may often be a stumbling block for CML. As Kearsley (1984) points out, the introduction of a computer system changes the power structure and roles within the organisation adopting them. These problems are contextually critical and may impede (if not prevent) good selection and effective implementation of CML. Some of the issues include:

- the presence of suitable people to develop and support the introduction of CML and its subsequent operation and maintenance;

- the attitudes of people to computers in general and the use of computers in managing learning in particular. This includes the extent to which the introduction and use of CML is supported; and

- the dynamics of the organisation including any interpersonal rivalries, the competition for resources, the relationship between individual units within the organisation and resistence to change.

The technical issues relate to the hardware and software actually available, or which might be needed, to allow a CML system to be introduced and used. The capabilities of hardware and software alike need to be specified and evaluated. These issues have already been discussed at some depth in this monograph.

In most cases in education and training areas there is only a limited amount of money available. Decisions on how this money should be spent are of considerable importance, and thus the cost issues are significant in determining what solutions to problems might or might not be possible. CML may have a relatively high initial cost, particularly if hardware and software have to be purchased and staff have to be employed or deployed to select, evaluate and it. If there is a learning program in place the costs of running it have to be known to determine whether CML represents a viable financial alternative in the long run. This viability may not be justified only on terms of running costs, but also on the other more peripheral benefits derived from its introduction. These benefits are often hard to quantify and may only become apparent some time after a commitment of funds has been made and the system introduced. Therefore the introduction of CML may really be somewhat of an act of faith because the significant benefits cannot be quantified and immediately demonstrated.

Many of the issues just discussed are addressed more specifically in the questions posed shortly. These questions have been inspired and adapted from the issues raised by both Kearsley (1984) and Muddle (1985).

System specification

If the problem has been well specified and the various issues identified so that it is apparent that CML is, at least, one of a number of possible solutions, the specification of the sort of system required becomes relatively easy. The context in which the CML system will be developed is apparent both from the instructional and organisational issues described. The issue of cost will set clear boundaries on the size and type of system possible. The technical issues addressed will indicate what is required technically of the proposed CML system. Thus the translation from problem specification to system specification should be a relatively simple one. However system specifications need to be weighted to ensure that features which are essential are differentiated from those which either are unnecessary or merely nice to have.

Information collection

Once the system requirements have been specified, the task of gathering further information begins. Those responsible for

selection can gather information in a number of ways. These include:

- demonstrations by vendors;
- review articles in books or journals;
- visits to conferences;
- discussions with individuals or organisations who have already purchased and implemented the hardware and/or software being considered;
- tenders by potential vendors who must demonstrate that their product meets the specifications developed; and
- pilot runs using the package(s) being considered.

A number of alternative systems may be identified by these processes, and the best of these should be selected for comparison.

Comparison of systems

This step enables the evaluation and comparison of each of the short-listed systems, which have already been chosen on the basis of the information collected about their features and capabilities. In evaluating each system information about the costs of running the system need to be gathered or estimated, and detailed performance tests of the proposed system(s) can be run. These tests, referred to as "benchmark tests" are used to generate comparative information about each of the alternative systems in operation. For example, the data gathered could include such things as:

- system response times;
- the number of keystrokes required to edit or add information to a learner record file; and
- time taken to enter and manipulate a data file, to test data, or to generate reports and tests.

In short, the process involves putting each system through its paces using a common testing system to determine how well each system actually performs in critical areas. This information is summarised, considered and from it a selection may be made.

Questions to ask about prospective CML systems

While many questions could be asked in order to specify a problem and thus develop a list of desirable attributes for a CML system, the following questions may prove a useful aid to the process.

Problem specification

- What are the parameters of the problem?
- What alternative approaches of solving the problem are available?
- Which of the approaches, if any, might be appropriate?
- What role, if any, could CML have in solving the problem?

Viability of CML

- Will the learning program(s) where CML could be used be around long enough to justify its use?
- Will the number of learners involved in programs be enough to justify using a CML package?
- Is there a need for on-demand delivery of a learning program - that is, how, when and where it is needed?
- Are resources limited and would their management be improved and facilitated using a computer?
- Would learners benefit from an individual approach to the management of their learning program? Woud this process be facilitated by using a computer?
- Would learner assessment be improved by using a computer managed testing system?
- Would the quality and amount of information available about a learning program for decision-making be improved by using a computer?
- Would the reporting of information (including information about learners) be improved by using a computer?
- Are the people who can design, develop, implement and operate a CML system readily available?
- What attitudes are learners and staff likely to adopt to the introduction and use of CML?

- Is support for CML widespread or limited within the intended context?

- Are organisational conflicts likely to affect the introduction and use of CML?

- What benefits are expected from the introduction of CML and are the expectations reasonable?

- What kinds of peripheral and communications devices might be necessary/desirable?

- Are the costs of the current learning program known? What are they?

- What would be the cost of developing, implementing and maintaining an appropriate CML system?

- Will the introduction of CML bring about cost savings?

- Are the funds available to meet the expected initial costs sufficient to assure successful introduction of CML?

- Can hardware and/or software be purchased by the time it is needed?

- Are the costs of introducing and maintaining a CML system acceptable to the organisation?

- Have alternatives to CML that may be a more suitable solution or have less impact on resources been considered?

Specifying the system

Many of the questions that have to be asked to help specify the CML system needed have already been asked in specifying the problem. Thus the questions posed below are focused on specific issues.

- What sorts of display characteristics are needed for the computer system (size, screen and the availability of colour, is available, resolution etc.)?

- How will information be inputted to the computer?

- What output characteristics are required?

- Does the system need to be portable or will it be used in one or more fixed locations?
- How secure does the system's hardware and/or software need to be?
- Who will be using the system?
- How much control over the system will those using it have? Or want?
- What management functions can the CML or CBT software perform?
- What hardware characteristics are needed to ensure that the software can perform?
- What suitable software is available?
- Who else has used this hardware and/or software and what do they think of it?
- What range of machines can the software be used on?
- How easy is the hardware and/or software to use?
- What response times are required for the system?
- How many terminals can the system support?
- What off-line storage capacity is needed?
- What amount of processing capacity (i.e. Random Access Memory) is required?
- What communications capabilities are built into the hardware/software?
- How easily can the individual items of hardware and software be interfaced?
- What service support is available for the hardware/software?
- What is the cost of this service support?

- Do any users or other support groups for the hardware/software exist?
- Can the package be tailored at reasonable cost for the different needs of its various users?
- What is the quality of the documentation supplied with the hardware/software?
- What training support accompanies the available hardware and/or software?
- Is maintenance of the CML package available from the supplier?
- Is the hardware/software capable of being upgraded?
- What will the hardware and/or software cost to purchase?
- How much will the system cost to operate?

7. SOME AVAILABLE CML SYSTEMS

The previous section discussed methods for selecting a CML system and a series of questions has been used to highlight factors which should be borne in mind when selecting a CML system. There is a number of systems available, and a few of these will be considered here. They can be large, complex and expensive or relatively small and simple. They may run on large, powerful computers or small micros. Their range of functions may be broad so that they represent CML in its pure form, or they may be focused on a particular aspect of learning management. Finally, a package may stand alone or be part of a larger computer based training package - for example, PLATO.

In the U.K.,Europe, and U.S.A., the early development of CML systems tended to trail behind the development of Computer Assisted Instruction (McMahon 1978). I will consider both large and small systems. Whether large or small, the systems described here are either used exclusively to manage learning, or they incorporate a management component in a more broad-ranging package. This section is intended as a guide to further reading, not as a definitive statement about each of the systems discussed.

Large systems

In the U.K. four major CML systems are described in an article by McMahon (1978). These systems are:

- the Havering CML system;
- the Hertfordshire CML system;
- CAMOL (Computer Assisted Management of Learning - which is produced by ICL); and
- CICERO, produced by the Open University.

Of these the Havering and Hertfordshire systems are schools based - as is the GEMS system (Goal Based Educational Management System) developed by the Jordan School District in Utah and described by Hofmeister and Maggs (1984).

CAMOL is described in detail in an article by Rushby et al. (1976). The computer programs for CAMOL were produced by a team at International Computers Ltd. (ICL). CAMOL was further developed or used by a consortium which eventually comprised The New University of Ulster in association with the Methodist

College, Belfast and the Ulster Polytechnic; Brighton Polytechnic; Bradford College with Keighley Technical College and Shipley College of Further Education; and the Trade Training School, Catterick (Rushby et al. 1976). CICERO was developed to support distance learning programs at the Open University and provide students with rapid feedback on their work by a method which is independent of other tutorial and correspondence services. The CML system used by Darling Downs Institute of Advanced Education in Toowoomba, Queensland for both on- and off-campus students is described in an article by Barker et al. (1985). The SAIT (Southern Alberta Institute of Technology) designed and produced a CML system which was described in a report produced in 1982 for the TAFE Board of Victoria on the statewide development of CML and CAI. The Executive Officer of that project, Robert Denholm, has since become the Australian representative of the Canadian-based company "Computer Based Training Systems Australia" (CBTS).[1] Richmond College of TAFE in Victoria is using a combination of the AUTHOR and SMRS packages. The Commonwealth Employment Service were reported to have purchased the Phoenix CBT system - which incorporates a CML facility (Scott 1984). Phoenix was also used by the Burlington Northern Railway (Joyce 1984). Control Data's PLATO system, which incorporates a learning management system (PLATO Learning Management or PLM), is being marketed by a West Australian based company, Computer Aided Learning Services[2].

A number of other authoring systems also include management components. These include COMBAT, the Interactive Instructional System (IIS) marketed by IBM, Mentor II and WISE (which runs on WICAT's own minicomputers). All of these systems, including Phoenix and PLATO, are described in greater detail in Dean and Whitlock (1983).

Smaller packages

A number of packages are capable of being run on microcomputers, particularly microcomputers with large central processing and storage capacities, or those which can interface with larger mini or mainframe computers. PLATO comes in a smaller version called MICROPLATO. The GEMS system has a microcomputer based

1. Their address is 16/39 Foley Street, Kew, Victoria 3101.

2. Their address is G20, 145 Stirling Highway, Nedlands, Western Australia 6009.

equivalent called CLASS (Hofmeister and Maggs, 1984). Microcomputer packages for test generation are described by Brodeur (1986). These include packages for Apple, IBM, TRS 80, Tandy 2000, DEC Rainbow and NEC APC microcomputers. In all, 16 packages are discussed.

Packages - a final note

Although there is a number of dedicated CML packages available commercially, and others which incorporate elements of CML, it is possible, even likely, that these will not meet the full range of identified needs. In this case, the development of a tailor-made system may be the only answer to the problem. This could be done using a suitable spreadsheet package, but it requires some computing expertise. However, until the range of commercially available CML systems available in Australia or overseas is adequately documented, or available for trial, or the CML packages are developed so that they are more adaptable to specific applications, the "made to measure" CML system will represent the only solution for a number of potential CML users. Hopefully, the day is not too far off when CML systems will become more generally available and applicable. The final section (Section 9) of this monograph deals with some of the prospects for CML.

8. IMPLEMENTING A CML SYSTEM

The selection of a suitable CML system has already been discussed. In selecting the system the feasibility of using CML was also considered, not only the technical and instructional aspects but also those concerned with issues of the organisational dynamics and costs involved.

The implementation of a CML system is largely an issue of managing its introduction and ensuring that sufficient funds are available as and when they are needed to purchase any necessary hardware and software, or to allow people to be introduced to the new system properly.

A number of key factors which can make or break the introduction of a CML system will be considered in this section. They include:

- clear goals;
- planning and commitment;
- staffing and staff development;
- user involvement;
- results;
- readiness;
- reliability; and
- resources.

It should soon be clear that these factors apply equally to the introduction of any new way of doing things - not just CML!

Clear goals

To ensure that everyone involved in the introduction of a CML system has a clear idea of the CML system's aims. This will ensure that, on the one hand, they will not expect too much of the innovation and, on the other, that they will not accept too little! There will also be problems if some believe that CML is being introduced in an exploratory way while others believe the organisation has made a wholehearted commitment to the system. Clear goals are a way of ensuring that implementation does not become diverted by a series of red herrings and side tracks. Clear goals are needed so that the organisation, and those within it, stay on the straight and narrow!

Planning and commitment

Having clear goals implies that proper planning has occurred. Without proper planning the introduction and subsequent development of a CML system will be very difficult indeed. Therefore, lead time has to be allowed in the implementation process to ensure that issues are discussed and potential problems considered and solved. In this way the system can be introduced with as few disruptions as possible. Alternatively a phased implementation could be planned - with a modest beginning and a gradual and controlled growth. Commitment to the achievement of goals from all those involved in implementing and using a CML system is required. If the commitment is limited to an individual, or only a few, literally thousands of ways can be found to subvert or prevent effective implementation. Commitment comes through those involved in the implementation, and those who are peripheral to it, understanding what is being attempted. This understanding needs to be extended to those who may only be peripherally involved. Commitment is built, in part, by the characteristics of staff involved, their interactions with others, and by staff development; for example, this staff development could provide training in, or an orientation to, CML. In this way, any resistance to change is not based purely on ignorance!

Staffing and staff development

To implement a CML system there has to be a sufficient number of staff with complementary expertise. Those primarily involved in developing and introducing the system may need technical skills, but they also need good "people skills". They cannot be seen by others as isolated cranks and technocrats. If they <u>are</u> seen that way, implementation will be difficult at best, impossible at worst. They may have to <u>sell</u> CML to their colleagues and to learners. If they have planned well they will have an implementable CML package. If they have talked to instructors, if they have run formal or informal activities to help instructors and learners alike to understand and to <u>use</u> the new system, then implementation should be relatively smooth and easy. Support mechanisms do have to be set up too. It's not a matter of throwing people hardware and materials and saying - "Here it is, now you can use it!" Documentation which is easy to understand has to be available, as does personal support. There need to be people around to whom users or prospective users can actually talk!

The CML system may have a simple teach yourself package. Alternatively, it could have a "help" key for those who experience difficulties with the system. Newsletters, telephone hotlines, bulletin boards but are a few of the many ways of providing users with the support they may need. All of this contributes to user involvement.

User involvement

The previous section was oriented towards introducing potential users to the CML system and, thus, building their commitment to it. User involvement means a sharing of control: it means - as Kearsley (1984) puts it - sharing "pride of ownership". If people haven't been involved or consulted they will feel no pride, they will have no commitment to implementing the system and making it work. If people are not involved they may, in fact, see their role as quite the opposite! They must be given an opportunity to contribute - and their contributions must be seen to be taken seriously. One cannot expect involvement from people who feel that they - and their legitimate concerns - are being ignored.

Results

The implementation of a CML system will produce results. Criteria need to be established which will demonstrate the success, or otherwise, of the system. Objective information based on these criteria needs to be gathered and reported so that those interested in the system can see how successful and useful it actually has been. Ways of measuring outcomes need to be found. If a wide ranging and valid evaluation system is built in from the start, the process of evaluation can do much to develop and improve the system further and allow users, critics and supporters of the system alike, to have their say.

Readiness

To be implemented effectively a CML system has to be ready. This readiness takes two forms. People using it need to be ready and able to make use of the system. The system itself also has to be ready for use, in that it should have been

tested to ensure that it will work properly. In some cases the technology actually being used may not be ready to be used in that role - it may not be sufficiently advanced, or reliable enough, to use under actual working conditions. Thus the testing system has to ensure that the system is tested in ways which mimic "real life" as closely as possible. Nothing is more frustrating to a user than a system which will not do the things it is supposed to do.

Reliability

A system which is not reliable is not likely to be acceptable to those who use it. If machine response times are slow and down time (that is the time the system is not on-line and able to be used) is high, people will not have confidence in CML. Nor will they regard it as satisfactory because it is clearly not able to help to deliver a program when, where and how it is needed - in a way which suits the learner. Likewise, if the instructors find the system is thwarting them (and their learners), support will diminish and implementation will be impaired at the very least.

Resources

To be successful a CML system needs the necessary resources. These can be in the form of hardware, software and other facilities; they may also be human or financial. Essential equipment may not have been purchased, suitable staff may not be available, physical facilities may be inadequate, little money may be left to maintain and run the system after it has been set up. All this may seriously affect the level and success of implementation. The solution, of course, is adequate planning to ensure that the resources needed to set the system up and keep it running, are available.

If all these factors are considered, then effective implementation of CML should be possible. Those planning the implementation however, should not be rigid, rather flexible and adapting to circumstances as they develop.

9. CML - THE PROSPECTS

This section is intended to consider briefly the future of CML and a few trends. Broadly these trends appear to be:

- advances in technology. These advances could take in many directions. Voice recognition may help to eliminate many security problems and it may be possible to interact with computers using the spoken word. Computers will become cheaper, more powerful and more compact; or other peripheral hardware will be developed and compatibility between systems will be improved - without sacrificing user friendliness. In fact, user friendliness will be enhanced because increasing capacity of the hardware will be able to cope better with the storage demands of user friendliness. Software developers will continue to improve the usability of software so that it is easier to use and more adaptable. Right now there is a real need for more and cheaper CML packages.

- increased expertise in the use of computers in learning. People are still experimenting with the ways in which computers can be used to manage and enhance learning. With increasing expertise, new users and new ways of using computers in the management of learning will be developed and implemented. However the increasing expertise will be wasted if organisations cannot adapt to make better use of the potential benefits of computers - both in managing and delivering learning. In addition, CML must not become tied to one view of student learning - it should be a means of removing old chains, but should not be a system which makes a whole new set in the process.

- greater computer awareness in society. As a society we are becoming more and more aware of computers and the impact they make on our daily lives. In the future people will be less able to bury their heads in the sand and ignore the computer. It will not only become a greater part of our daily life - we will not only use it more - but as our leisure time increases, its use in productive leisure time activities will also increase. The computer may not only manage our vocational training and development, but it may also be used to help us to manage other elements of our total personal development program, both as an individuals and as members of society. The possibilities for managing

and delivering information and educational programs by computer are potentially limitless. The contribution they can make to opening up learning are limited only by our present conceptions.

In all this however we must not lose sight of the fact that computers are tools - they serve a human-inspired purpose. While they can be used to impose greater controls on people, they are also a means of bestowing greater freedom. The balance between freedom on the one hand, and control on the other will be an important consideration in our future use of computers in learning management. In this sense the computer (and computer managed learning in particular) offers a real opportunity to make learning more open and available.

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A GLOSSARY OF TERMS

Central processing unit	the unit in a computer which controls and executes the instructions or commands given to the computer.
Digital pad	a way of inputting information into a computer using a finger or some other means of indicating a point. The position of the point is translated into a digitised form. Such devices may have a role in testing.
Disk drive	a mechanism for rotating a disk (see floppy disk) and controlling its movements so that the desired information can be read from or stored on a disk.
Floppy disk	a thin flexible disk usually used in microcomputers and enclosed in a protective jacket. Floppy disks come in a variety of sizes. They may have data stored on one or both sides and be of single or double density. Their storage capacity varies.
Graphics tablet	a more sophisticated version of a digital pad whereby points and lines can be entered in the computer in a digitised form. Examples of their use include computer aid drafting and design, cartography, civil engineering and circuit board design. They may also be used in testing.
Hard disk	a rigid storage disk which may be in a stand alone unit or incorporated in the body of the computer. It is capable of storing more information than a floppy disk and this information can usually be accessed more rapidly.

Hardware	a term describing all the physical equipment used in computers; for example, printers and other peripheral devices, disk drives, central processing units etc.
Keyboard	a device for entering information onto a computer by depressing appropriate keys. The keys may be arranged in a number of ways. Function keys, keys that have specific commands or do specific things, may be incorporated as part of the keyboard.
Mainframe	a general purpose computer with a large processing and storage capacity which usually serves the needs of a large organisation or those of a number of organisations who share its use.
Mark sense reader	a device for reading marks made on a card or sheet of paper. These devices may "read" information electrostatically or optically. In electrostatic readers the information may be sensed using the carbon in a pencil mark. Optical card readers rely on reflected light.
Menu	a means of displaying the range of available alternative functions which can be selected by the person using the computer.
Microcomputer (Micro)	a term applied to small computers which can usually fit on a desk top. They are manufactured by a variety of makers. They can be made up (or configured) to meet a variety of needs. Extra circuit boards and other devices can be added as necessary.

Minicomputer	a term used to describe those computers whose size and power falls between a mainframe and a microcomputer. They are larger and more powerful than a microcomputer, but lack the storage and central processing capacity of a mainframe.
Modem	is known as a MOdulator - DEModulator in other words it is the device which modulates the transmitted signal at one end of a network while another similar device demodulates the received signal at the other end. It is used to help connect two or more computers which might be separated by some distance using the telephone network.
Off-line	is used to describe computer equipment or hardware which is not connected to either a computer or a network and which is performing functions independently (ie. without the supervision) of other equipment in a network.
On-line	is used to describe computer and communication equipment as well as other hardware which is actively connected to a computer, another computer, a communication channel or network.
Peripheral device	a device which performs an auxilliary function in a system.
Software	the computer programs and their associated documentation concerned with the operation of the computer hardware.

Storage device — a means of storing raw or processed information. Such devices include magnetic tapes (such as cassette tapes) as well as floppy and hard disks. Video discs and videotapes are also forms of storage devices.

Videodisc — a disk which contains recorded motion or still pictures and sound. It may be controlled using its own microprocessor or by computer. If it is used interactively it can respond to those using it.